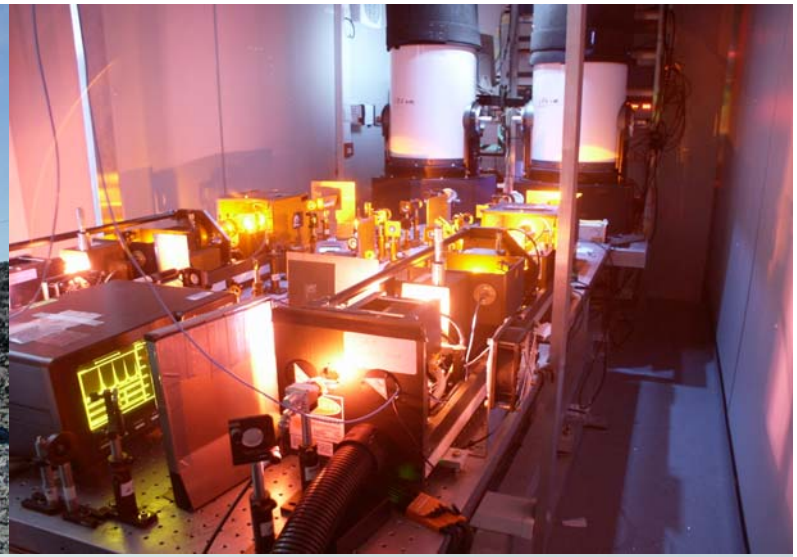
ASEN-6519 Lidar Remote Sensing



Lecture 01. Introduction of Lidar Class

Instructor: Xinzhao Chu

Assistant Professor, Department of Aerospace Engineering Sciences

Fellow, Cooperative Institute for Research in Environmental Sciences

LIDAR: What and Why?

LIDAR stands for Light Detection and Ranging, commonly known as Laser Radar.

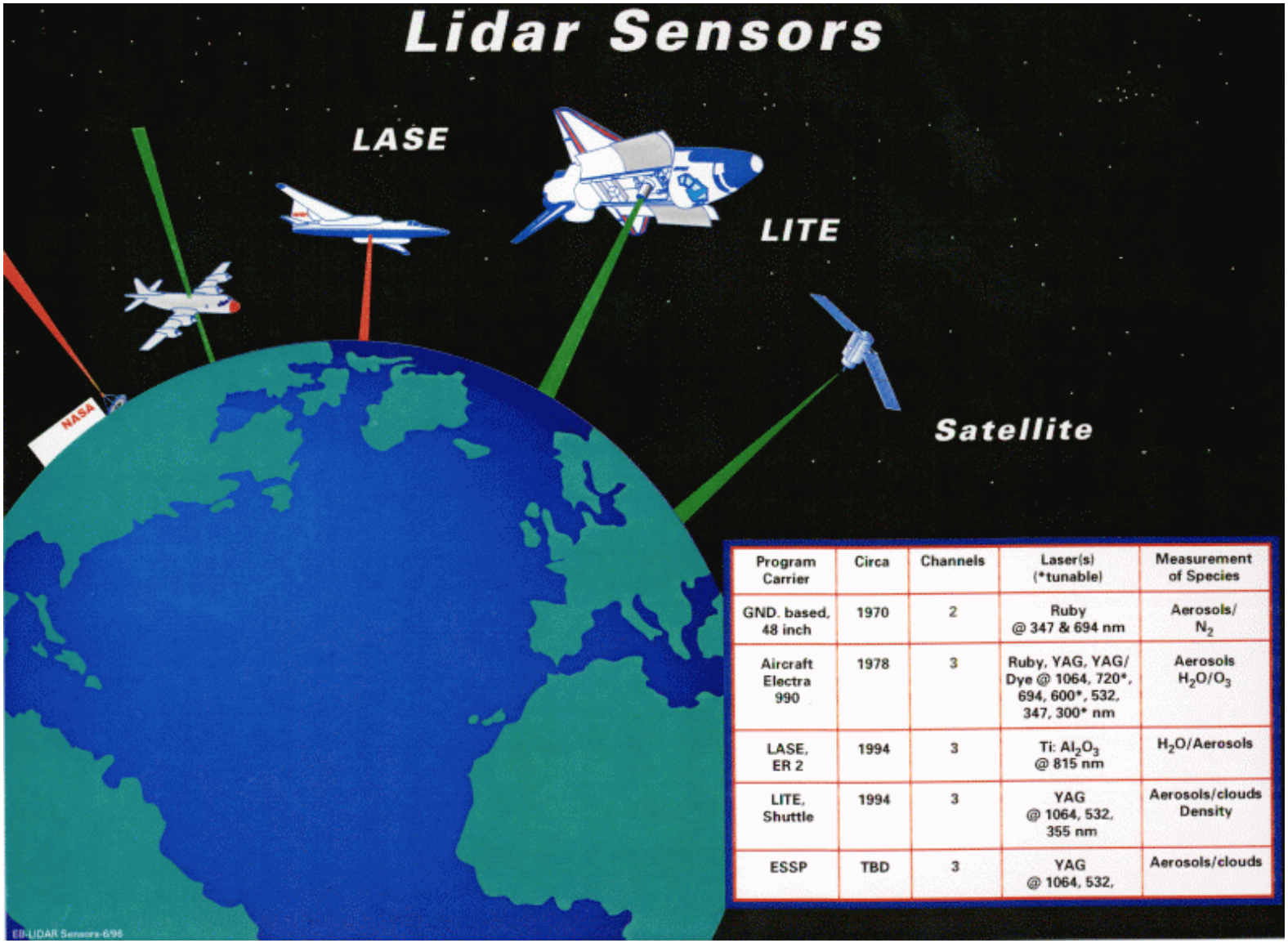
Lidar is not only replacing conventional sensors, but also creating new methods with unique properties that could not be achieved before.

Lidar is extremely useful in atmospheric and environmental research as well as space exploration. It also has wide applications in industry, defense, and military.

LIDAR: **Li**ght **D**etection **A**nd **R**anging

- Send light to the atmosphere
- Record light scattered by the atmosphere as function of time
- Convert time of flight to distance
  (1 ms ~ 150 km)

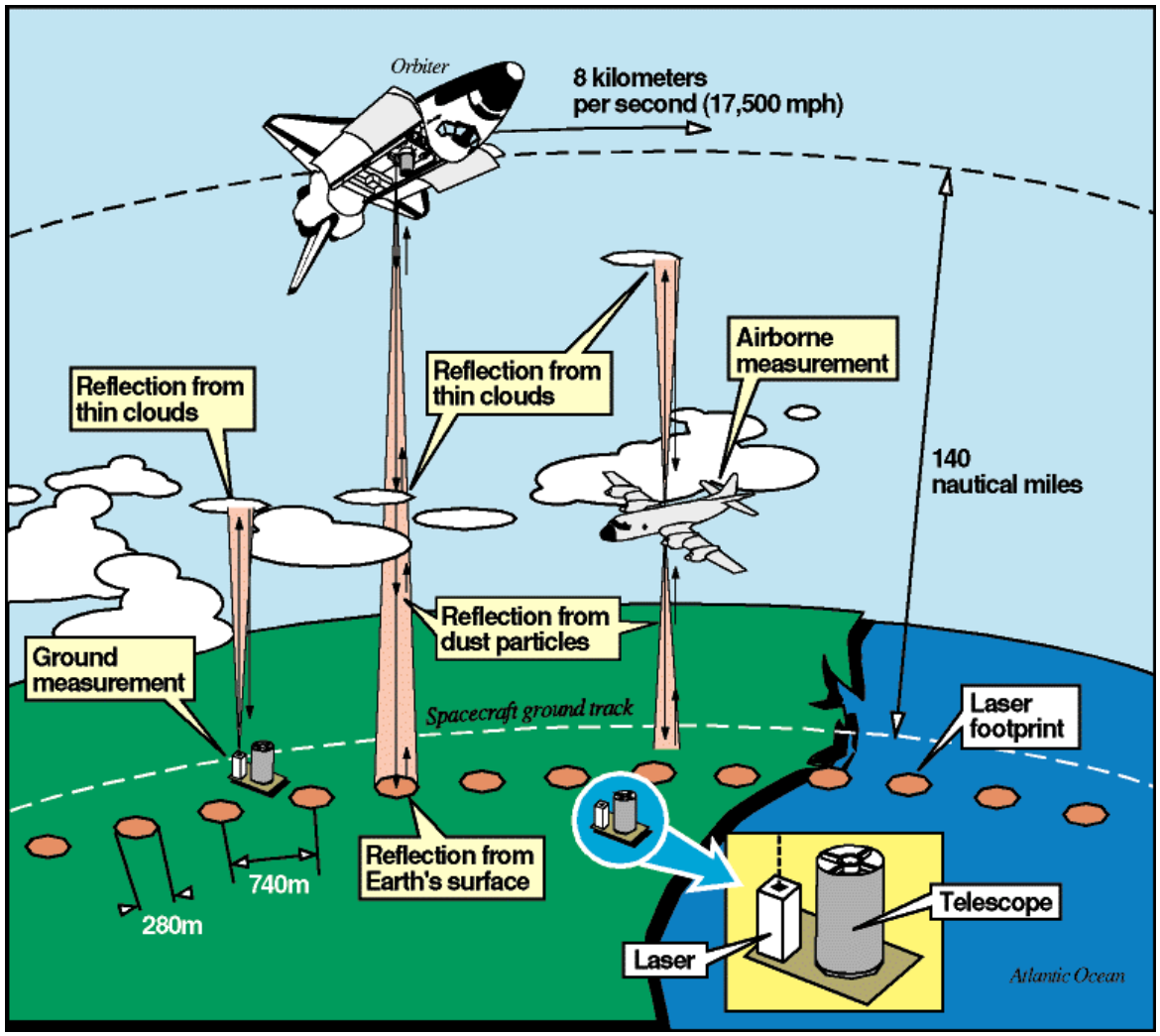
Lidar from Ground to Space



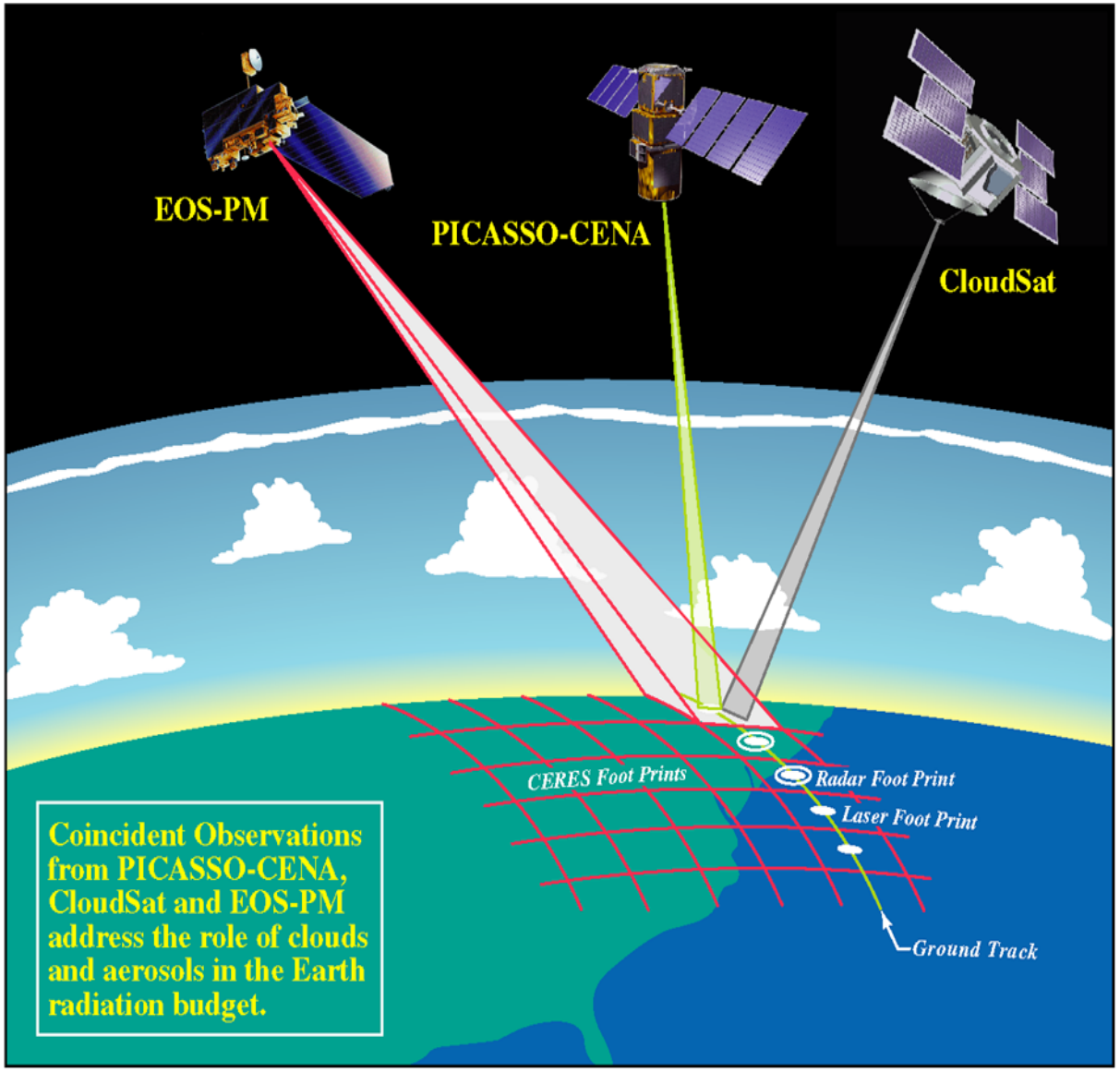
Program Carrier	Circa	Channels	Laser(s) (*tunable)	Measurement of Species
GND. based, 48 inch	1970	2	Ruby @ 347 & 694 nm	Aerosols/ N_2
Aircraft Electra 990	1978	3	Ruby, YAG, YAG/ Dye @ 1064, 720*, 694, 600*, 532, 347, 300* nm	Aerosols H_2O/O_3
LASE, ER 2	1994	3	Ti: Al_2O_3 @ 815 nm	H_2O/Aerosols
LITE, Shuttle	1994	3	YAG @ 1064, 532, 355 nm	Aerosols/clouds Density
ESSP	TBD	3	YAG @ 1064, 532,	Aerosols/clouds

NASA LITE Mission

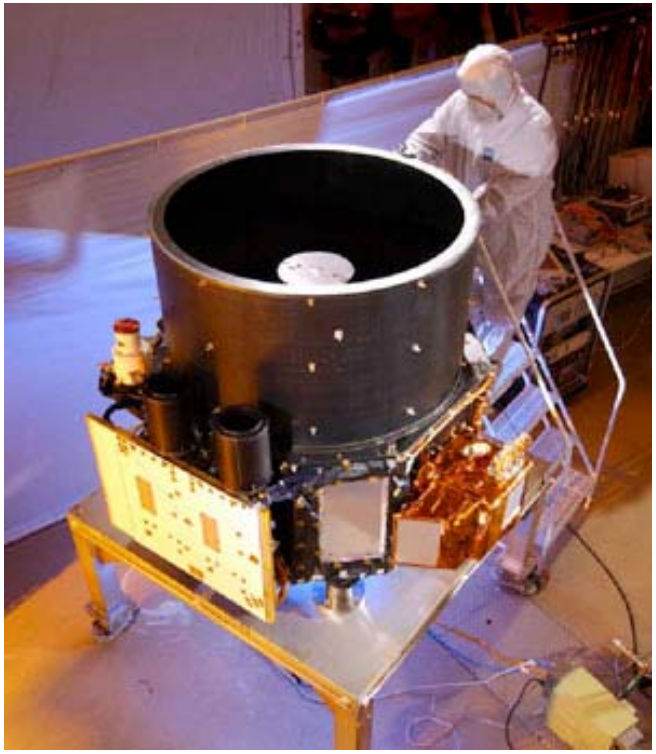
Lidar aboard Space Shuttle Discovery

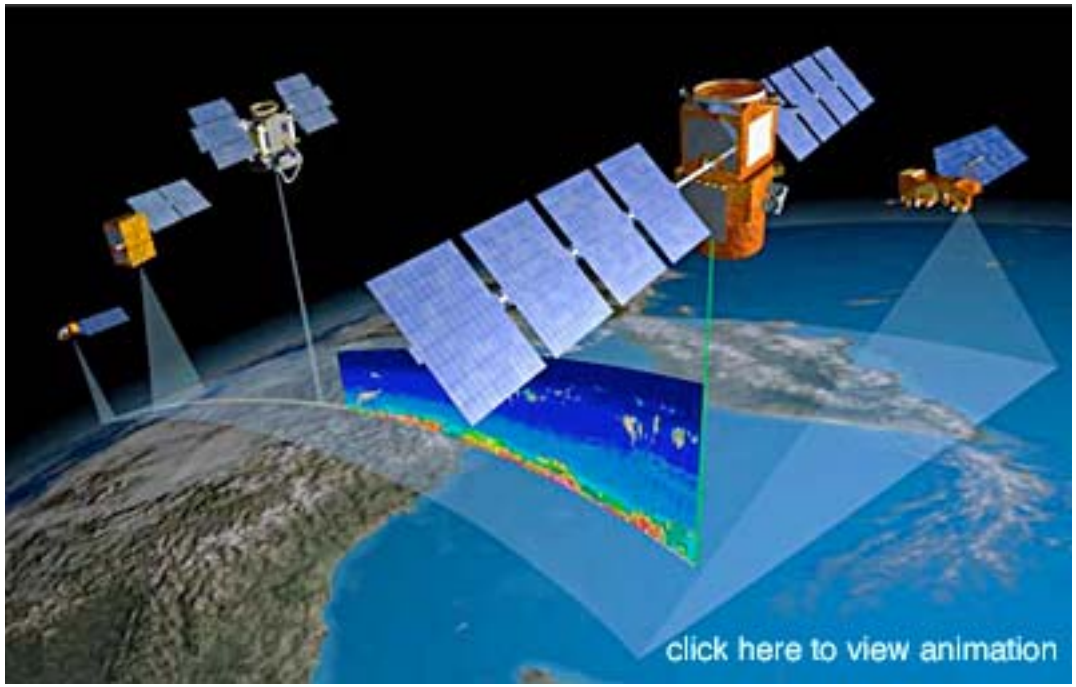


Lidar aboard Satellites



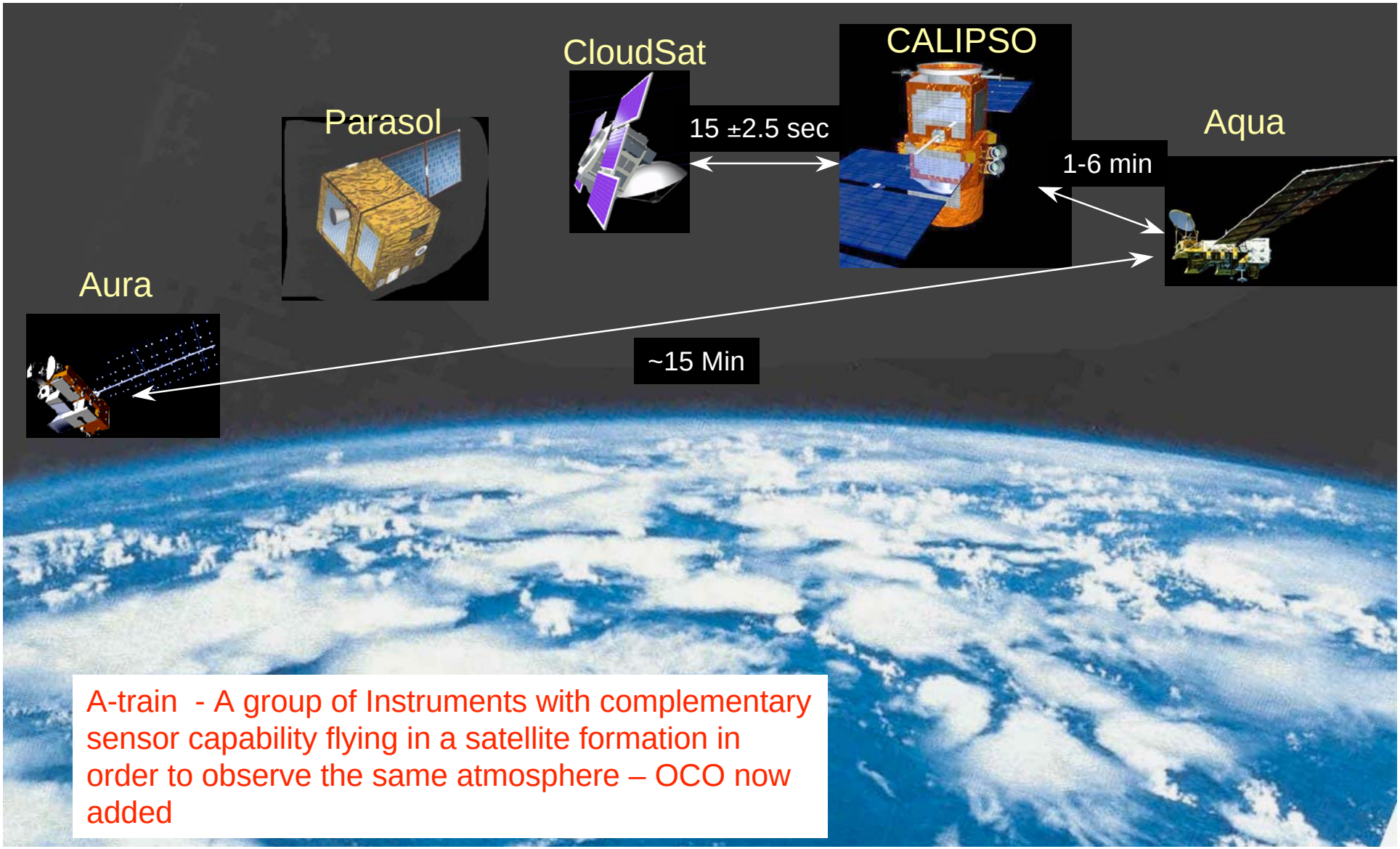
CALIPSO: Lidar on Satellite





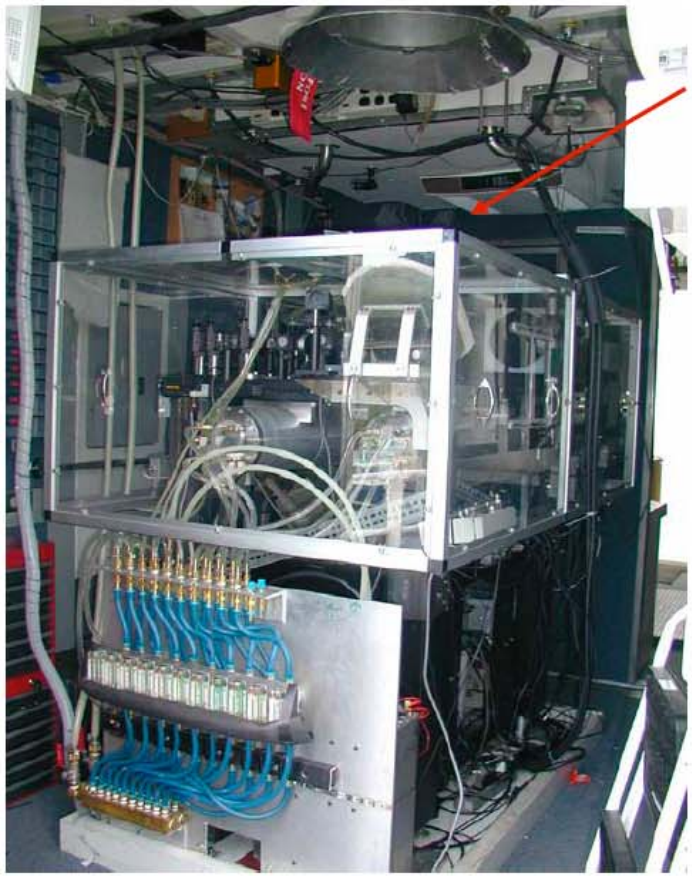
http://www-calipso.larc.nasa.gov/

Aqua (A) Train for Multiple Observations

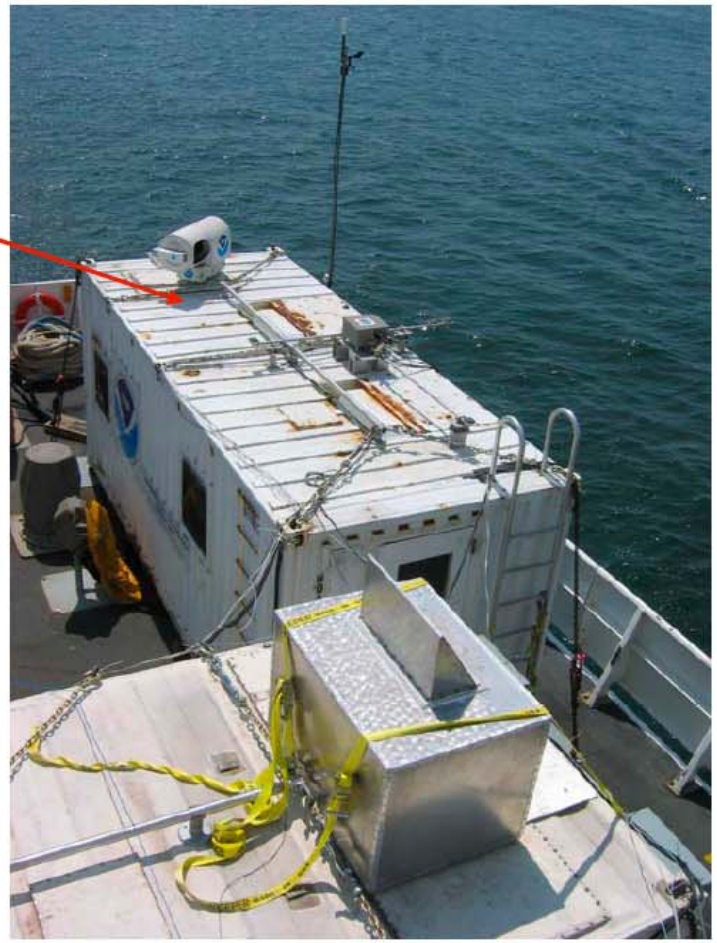


A-train - A group of Instruments with complementary sensor capability flying in a satellite formation in order to observe the same atmosphere – OCO now added

NOAA ESRL Lidars on Ocean



- Mini-MOPA
- HRDL
- OPAL
- TOPAZ
- DABUL
- Fish Lidars
- TUV
- CODI
- TEAC0
- ABAeL



Basic Lidar measurements

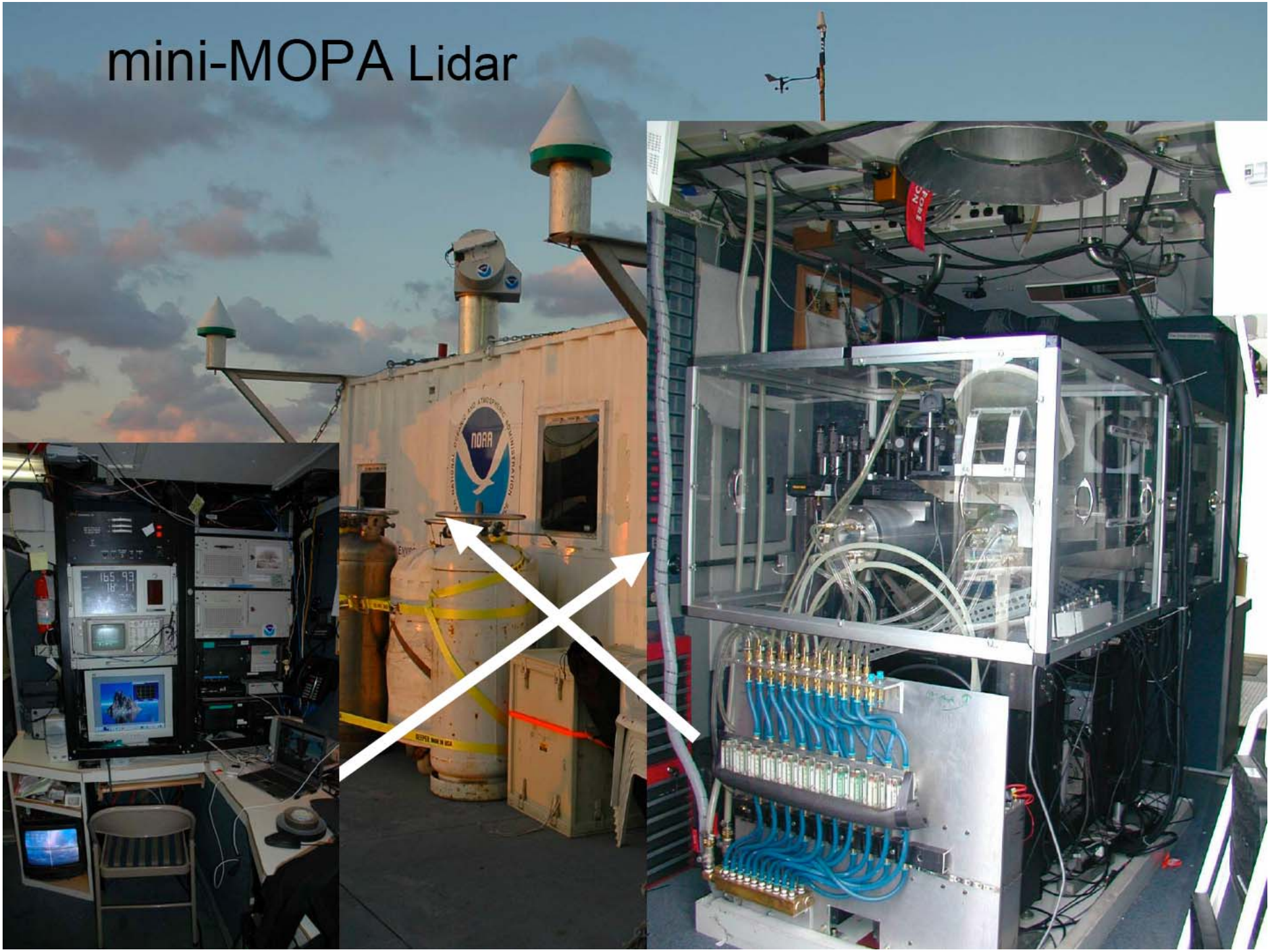
- Chemical distributions (ozone, water vapor, NH3, CO2)
- Cloud properties
- Aerosol measurements
- Low level mean winds
- Residual winds
- Turbulence, general dynamics

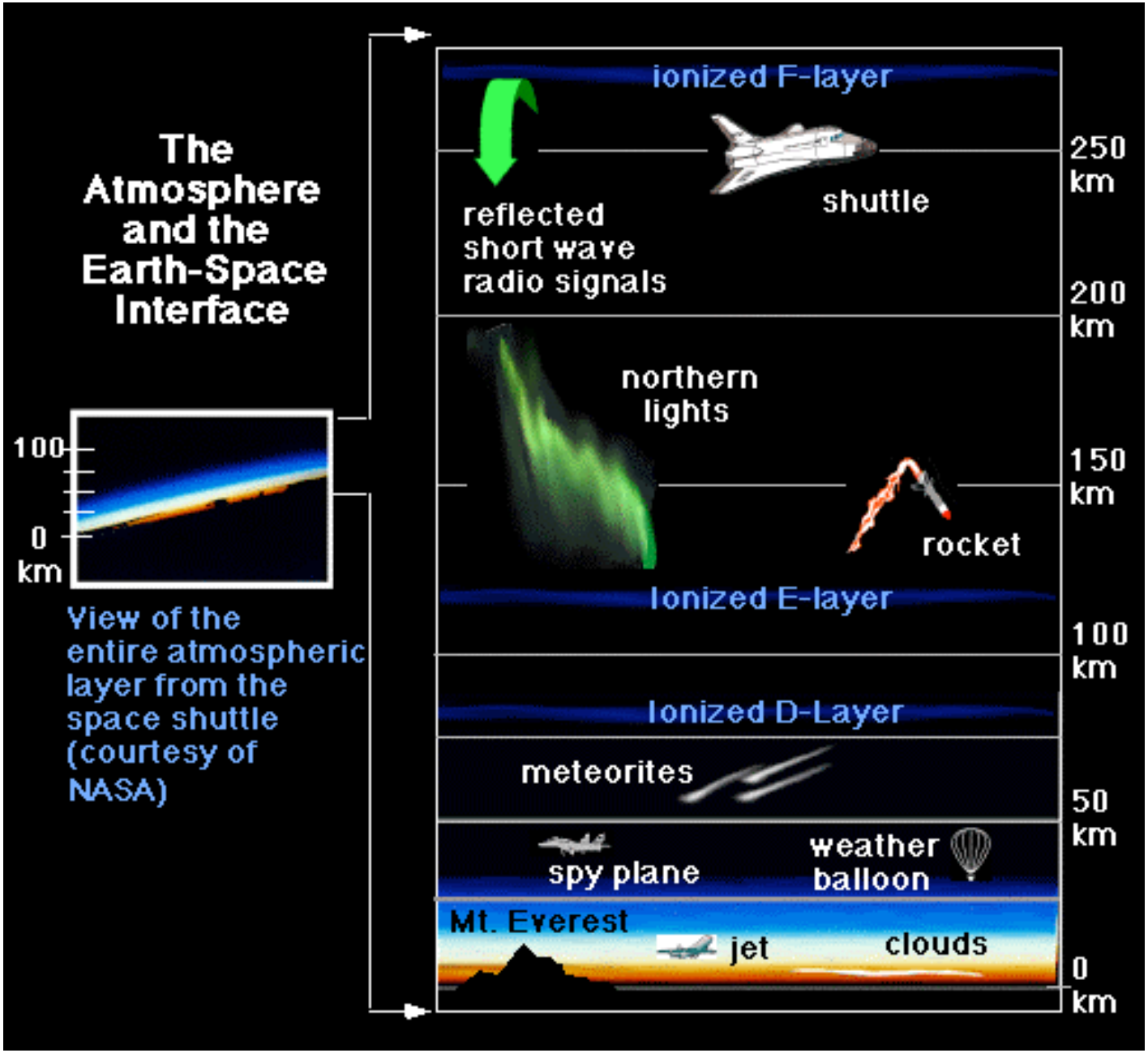
Instruments have been mounted on research ships for sea based operation

Challenges include:

- Sea salt corrosive environment
- High vibration
- Platform motion & orientation
- Low frequency accelerations – stability issues
- Big waves and leaky seatainers

mini-MOPA Lidar

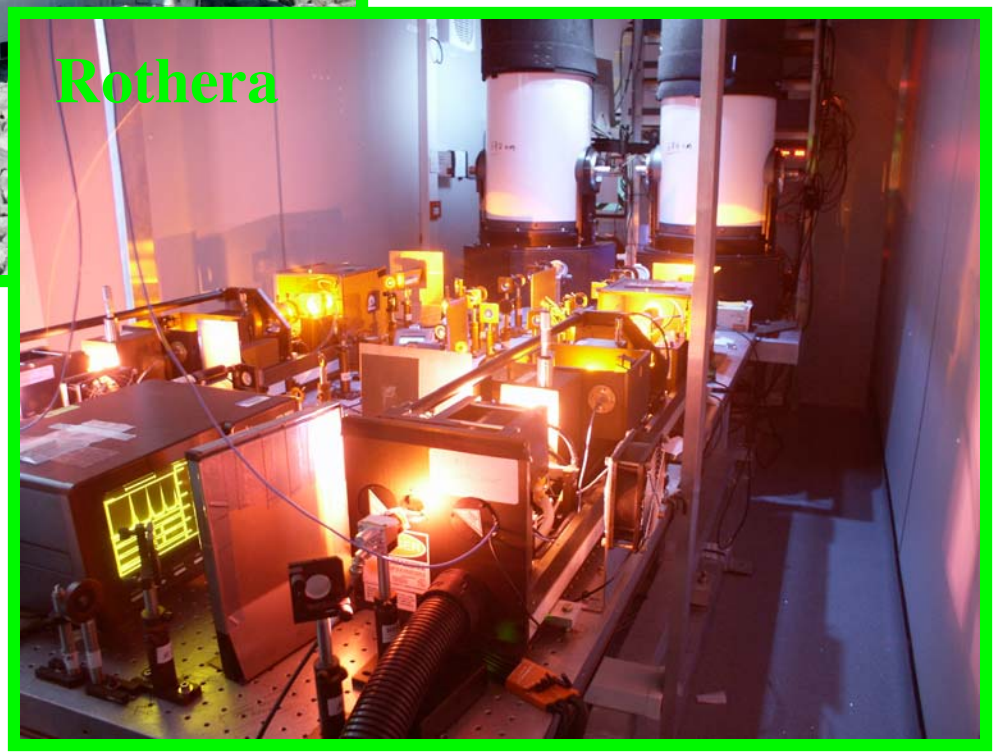



The Atmosphere and the Earth-Space Interface
100
0
km
View of the entire atmospheric layer from the space shuttle (courtesy of NASA)
ionized F-layer
reflected short wave radio signals
shuttle
250 km
200 km
northern lights
150 km
rocket
Ionized E-layer
100 km
Ionized D-Layer
meteorites
50 km
spy plane
weather balloon
Mt. Everest
jet
clouds
0 km

NSF/NCAR Electra Aircraft

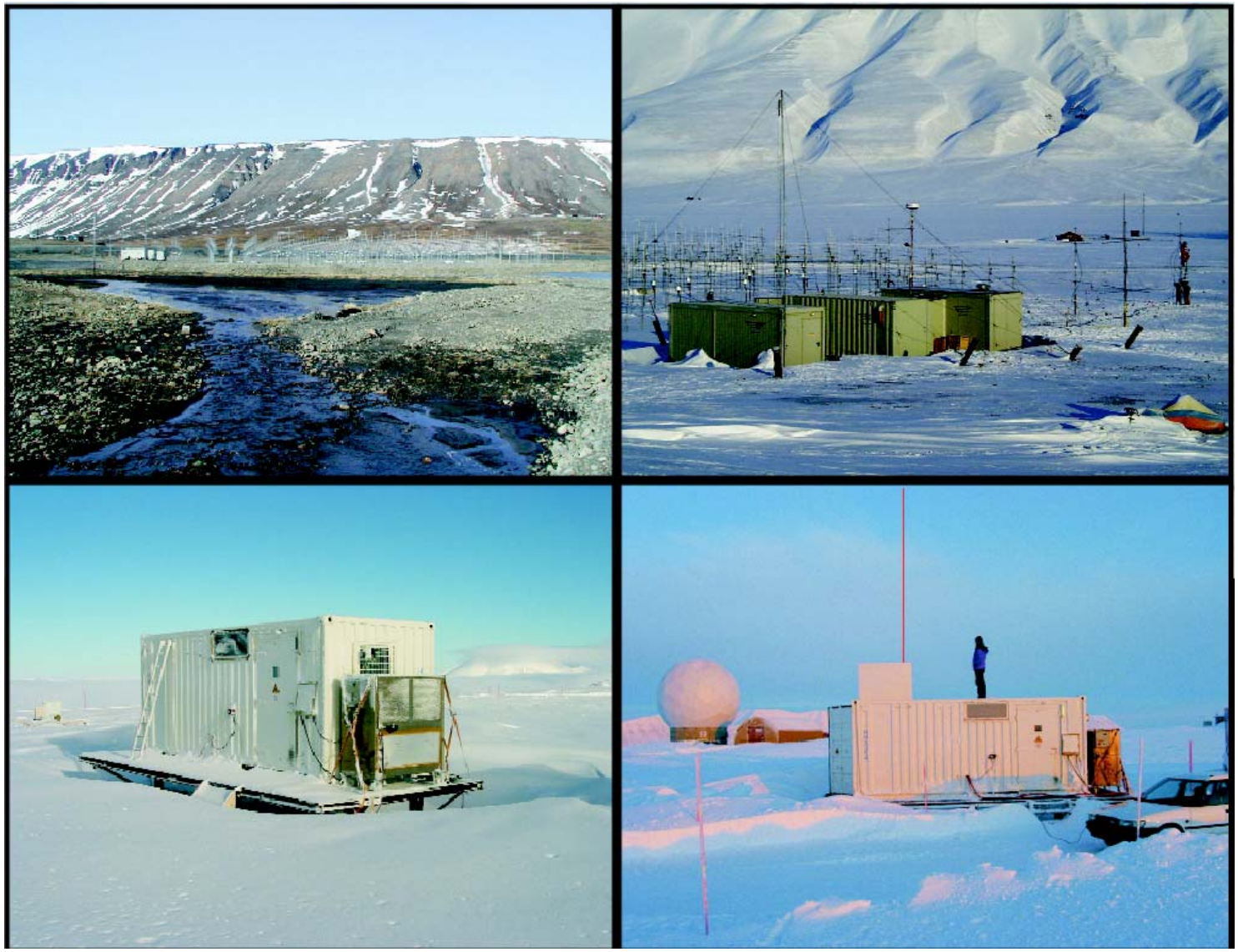
Airborne Fe Boltzmann Lidar

Groundbased Lidar at the South Pole



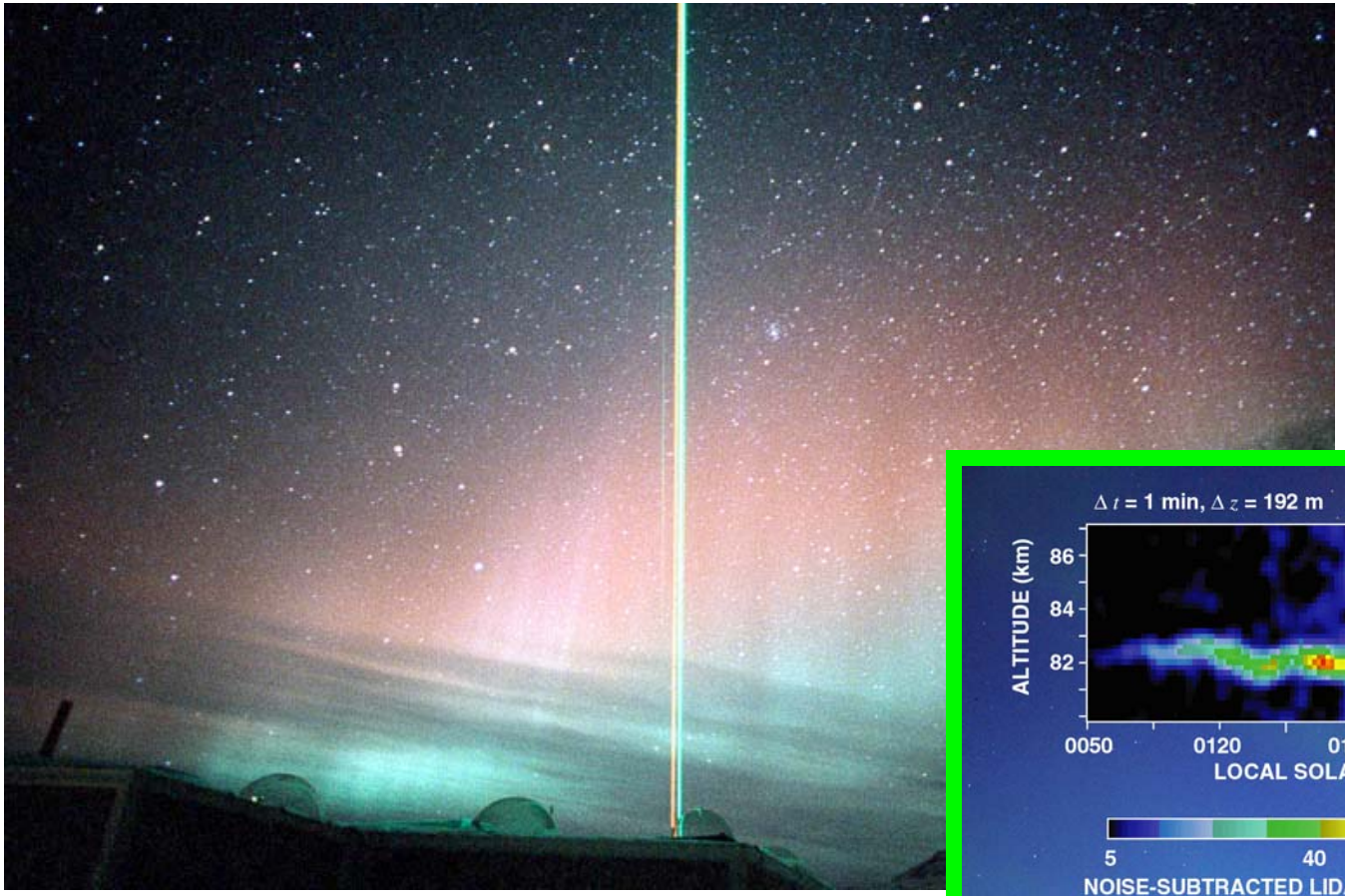
Containerized Lidar at Rothera, Antarctica

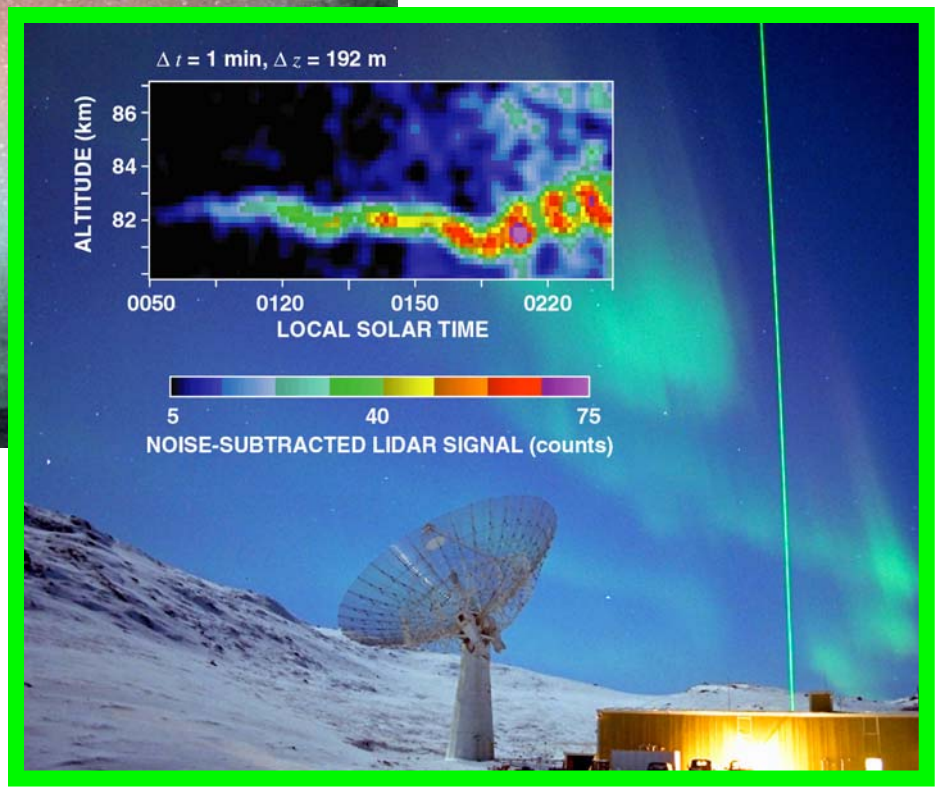
Containerized Lidar at Svalbard



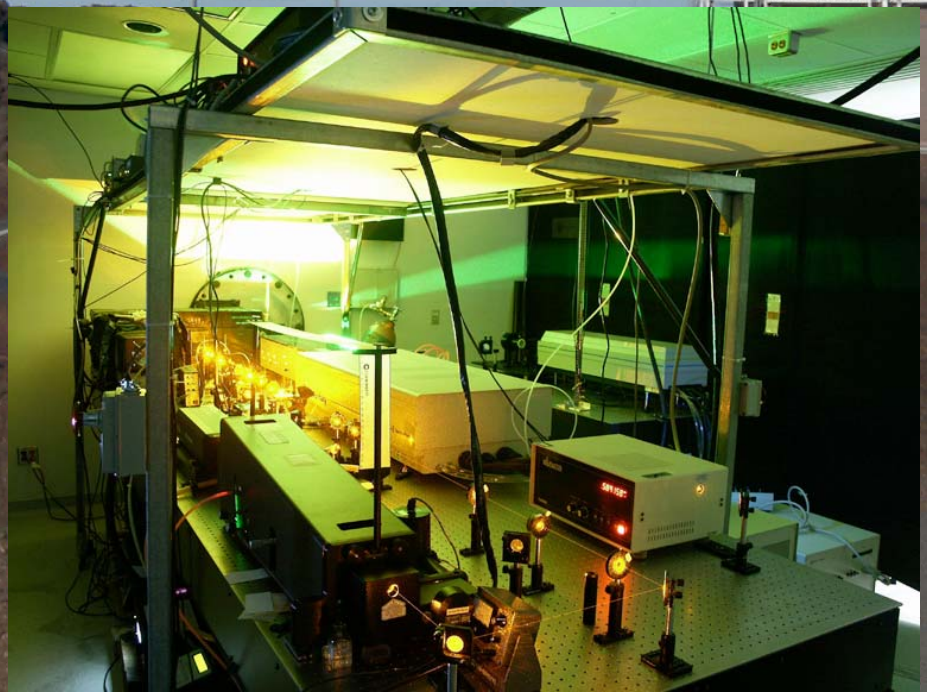
Andoya Rayleigh & Na Lidars

Sondrestrom Rayleigh Lidar

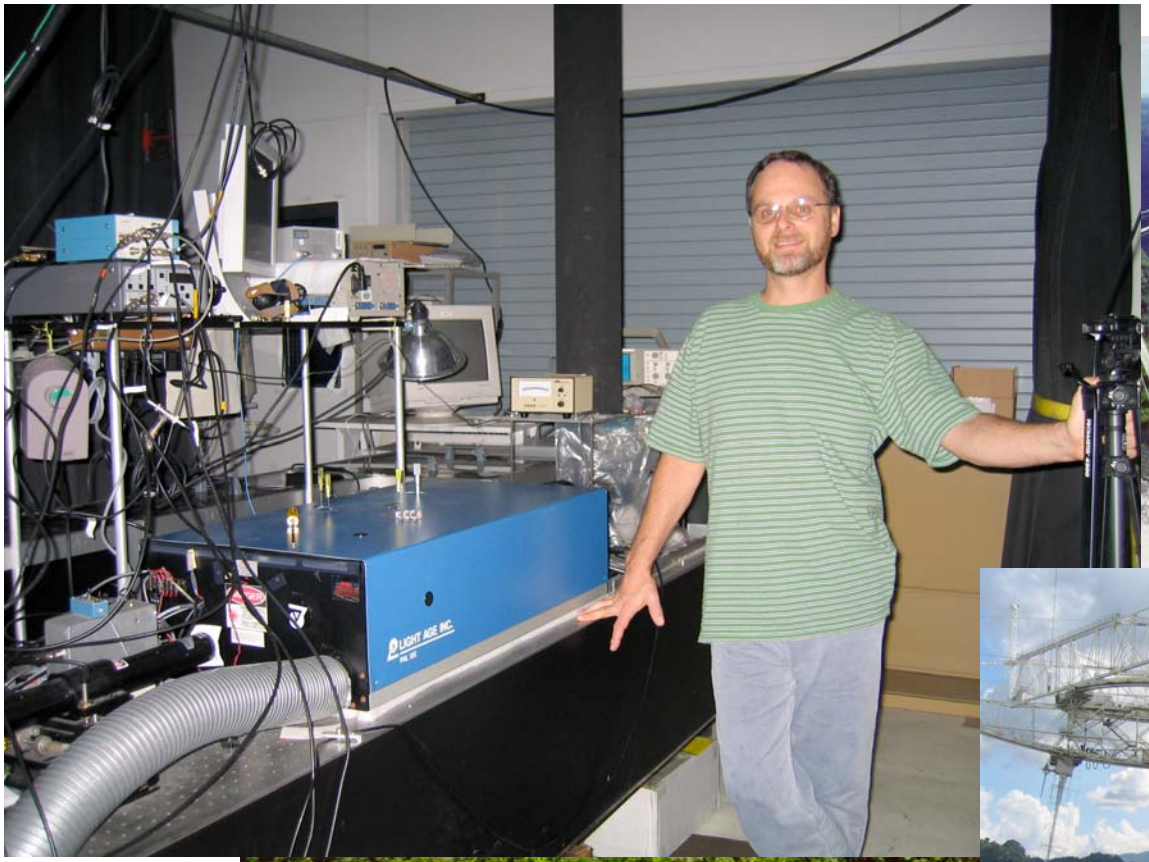


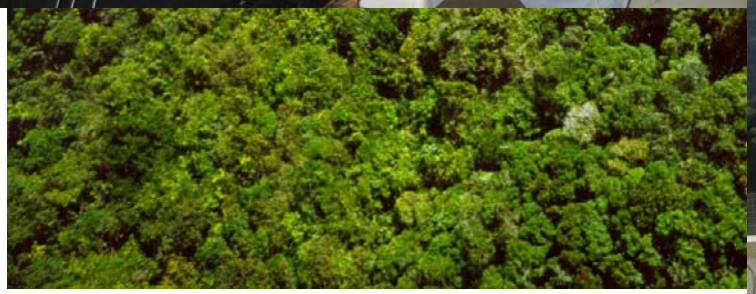


Large-Aperture Na Doppler Lidar at SOR, NM and Maui, HI



Arecibo Observatory K Doppler Lidar





Why Lidar Course?

This 6000 level class is based on the previous 5000 level "Laser Remote Sensing" class offered in Spring 2006.

But it has been significantly upgraded to include more lidar examples, lidar data processing projects, and lidar design components.

Students will be offered field-trip opportunities to CSU Fort Collins lidar facility.

Guest speakers will be invited from different lidar groups.

Lidar Course Objectives

1. A comprehensive, yet easily understandable, up-to-date overview of lidar principles, technologies, and applications;

2. Practice of lidar data retrieval, lidar system design, and quantitative analysis of lidar performance and measurement errors;

3. Opportunities to see and possibly operate the real state-of-the-art lidar systems and make connections to lidar experts in the nation and world.

Textbook and Reading Materials

Textbook:

"Laser Remote Sensing" (2005)
edited by Fujii and Fukuchi

Major Reference Books:

"Lidar" (2005)
edited by C. Weitkamp

"Laser Remote Sensing: Fundamentals and Applications" (1984)
by Raymond Measures

Reading Materials will be posted on the webpage.

Course Format

1. PPT presentation in classroom

2. Lecture notes posted at the class webpage:

http://cires.colorado.edu/science/groups/chu/classes/

3. Reading books and materials with reports

4. Projects as homework with presentations in class

5. Field Trip to CSU, NOAA and/or NCAR

6. Guest lectures

How to study this course?

1. Read books and lecture notes prior to classes, especially if lack of background
2. Listen to the lectures and try to understand the most in classes
3. Review lecture notes and read books and materials
4. Do projects to apply learned skills and check concepts
5. Ask and discuss with instructor and classmates to get clear concepts
6. Visit instructor's research group to look at real instruments and real applications

Grading Policy

10% Reading Reports: your understanding to lidar principles, technologies, and applications

80% Projects:

(1) Data retrieval and error analysis (e.g., Na density, Doppler temp and wind, Boltzmann and Rayleigh temperature, coherent wind, HSRL aerosol, edge filter wind, DIAL, or Raman lidar data)

(2) Lidar design and performance analysis

(3) Lidar simulation tools

10% Presentations: your results from projects and presentation skills

100-point grading system for each report, project, and presentation

Office Hours in Spring 2007

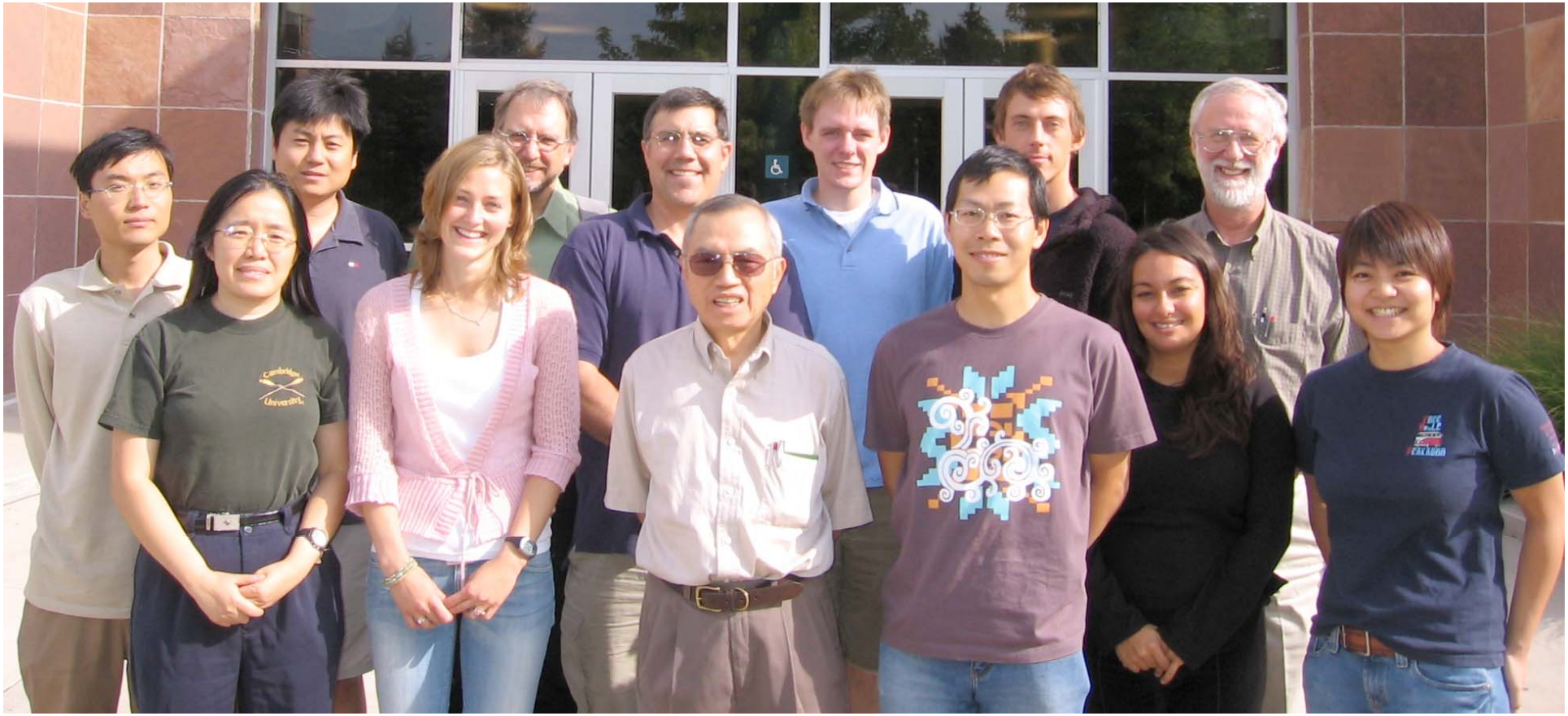
Lectures: M. W. F. 2:00-2:50pm @ MUEN D439

Office hours: Wed. 3:00-5:00pm
and stop by office at any time

@ CIRES 241 or 1B49

Questions regarding
lecture contents & projects & other lidar related

Guest Lecture --
Prof. Chiao-Yao She (CSU)



Guest Lecture --

Dr. Sara Tucker (NOAA)

Guest Lecture --

Dr. Carl Weimer (Ball Aerospace)

CRRL: Consortium of Resonance and Rayleigh Lidars

Lidar Consortium Technology Center

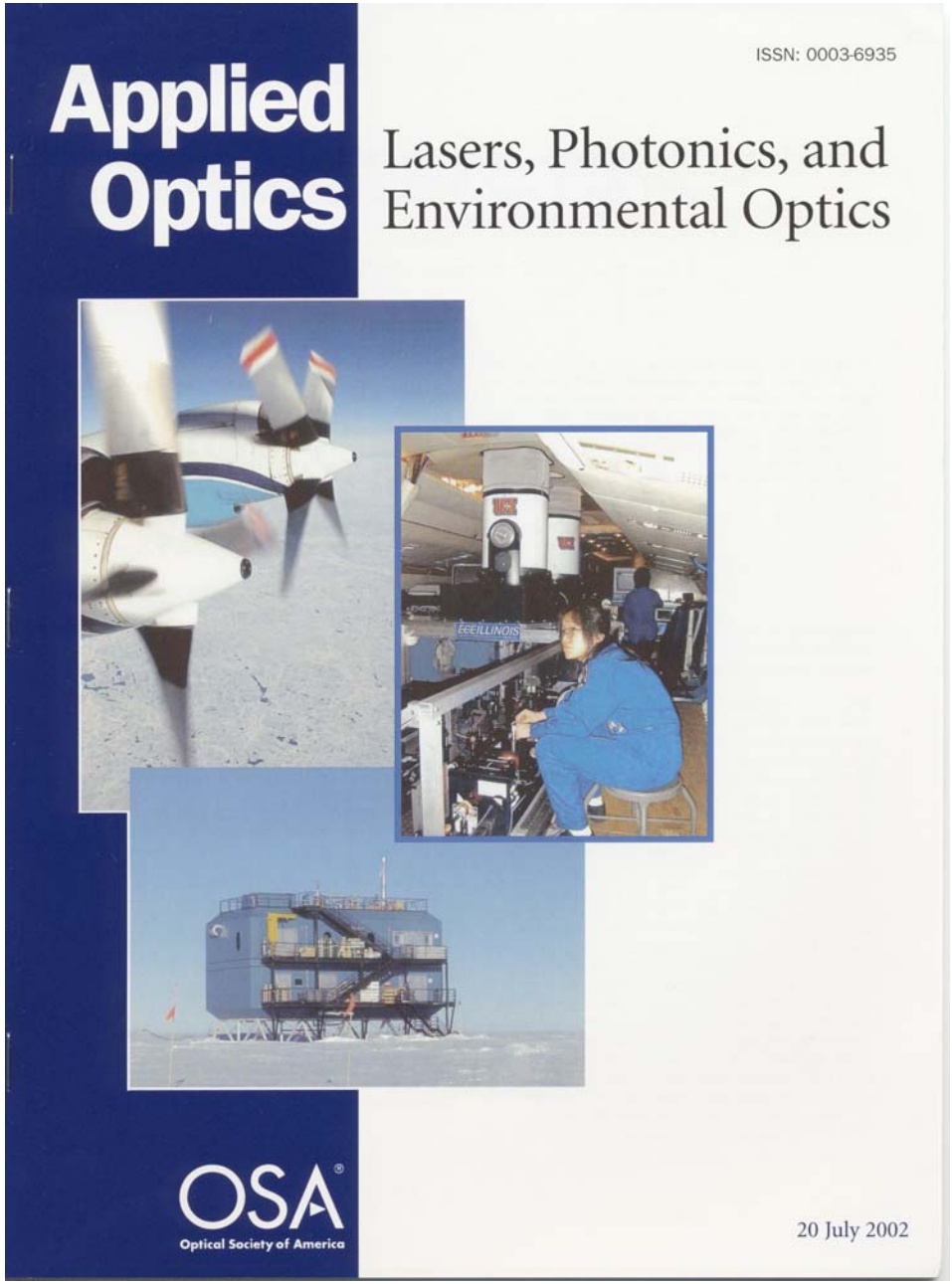
Community Center for Excellence

http://crrl.colorado.edu/

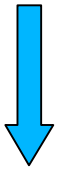
http://crrl.colorado.edu/phpBB2/

Good projects will be used at the CTC website!!!

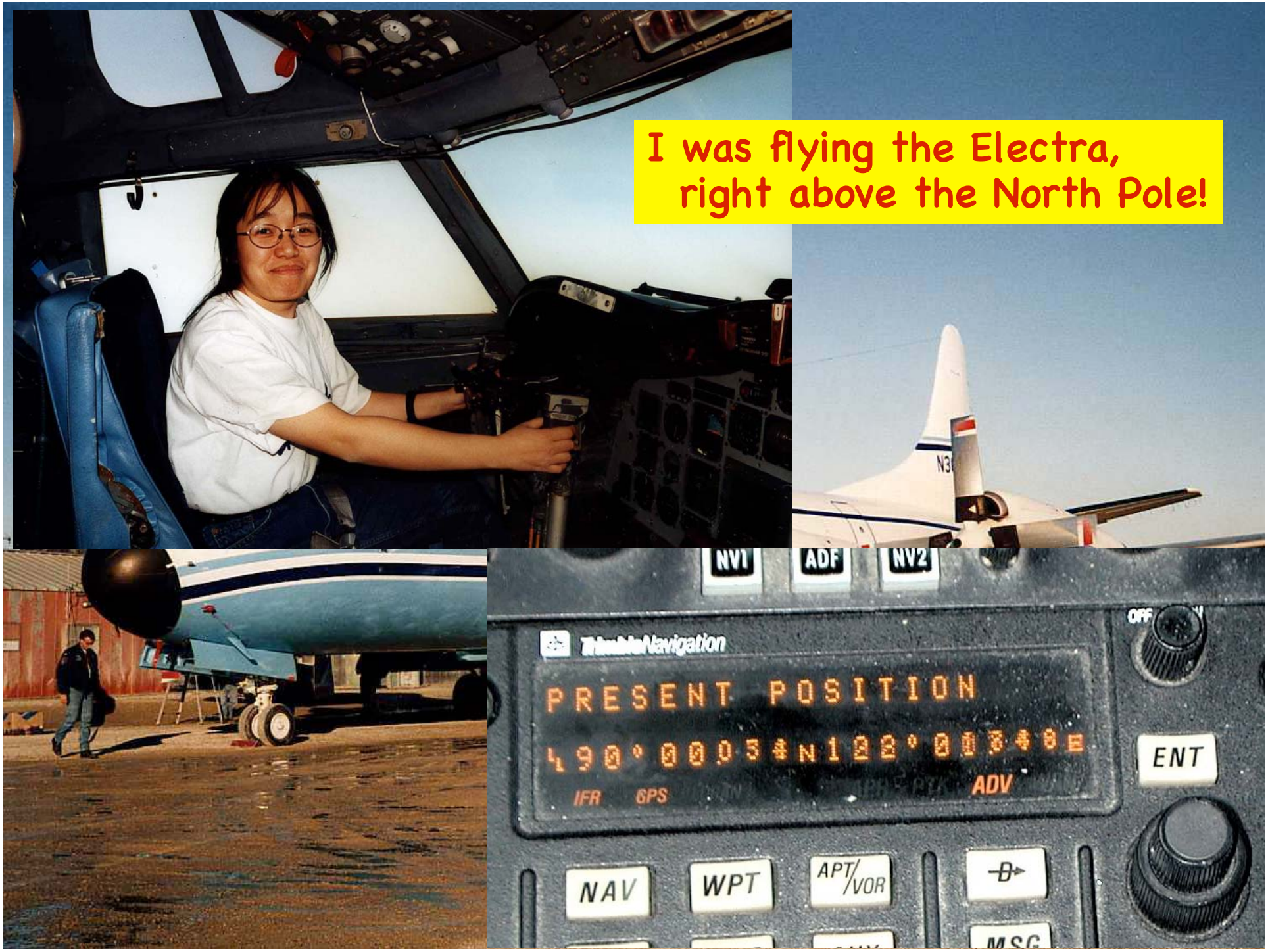
Pole-to-Pole Expedition



21 June 1999
Over the North Pole



24 November 1999
At the South Pole


I was flying the Electra,
right above the North Pole!
NV1
ADF
NV2
OFF
PRESENT POSITION
IFR
GPS
ADV
ENT
NAV
WPT
APT/VOR

Pole-to-Pole Expedition: South Pole

Summary

We expect an exciting adventure through the wonderful "lidar remote sensing" field …

Hope you will stay with us in the journey …

Let us work together to make advancement and contribution to lidar and lidar application.